ME3023 Lecture - Chapter 4

Probability and Statistics

Theory and Design for Mechanical Measurements

5th ed. by Richard Figliola and Donald Beasley

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• 4.1 - Introduction

Who has taken a statistics class before? In college? In high-school?

What does probability and statistics have to do with mechanical engineering?

For a given set of measurements we want to quantify...

- **a representative value that characterizes the average of the measured data set**
- **a representative value that provides a measure of the variation in the data set**
- **how well the average of the measured data set represents the average of the entire population**

- **4.2 - Statistical Measurement Theory**

  - **Where does the measured data set come from?**

  - **Sampling refers to repeated measurements of the measured variable under fixed operating conditions.**

  - **We will ignore systematic error for this discussion, is this valid?**

  - **Instead we will focus on random error, its affects and how to quantify it.**

  - **Question: If the error is really random error, what is the average error?**

- **We want to estimate the true mean, x' from repeated measurement of x.**

- **The true mean, x' is the average of all possible values of x. We never actually get this!**

- **Through sampling we can find $\bar{x}$, the sample mean value of x. We do get this!**

- **As our sample size increases, $\bar{x}$ approaches x'.**

$$x' = \bar{x} \pm u_{\bar{x}}$$

- **Therefore, the sample mean $\bar{x}$ is the most probable estimate of the true mean x'.**

- **$\pm u_{\bar{x}}$ is the uncertainty interval in that estimate at some probability level, P%.**

- **The uncertainty interval is the range about $\bar{x}$ that you would expect x' to lie.**

- **Probability Density Functions**

  - **The frequency with which the measured variable assumes a particular value or interval of values is described by its probability density function.**

  - **If a central tendency exists we should be able to see this in the probability density function.**

  - **As binsize of the histogram of the data set goes to zero this becomes the probability density function.**

- **4.2 - Describing the Behavior of a Population**

The true variance is:

$$\sigma^2 = \int_{-\infty}^{\infty} (x - x')^2 p(x) dx$$

For discrete data this becomes:

$$\sigma^2 = \lim_{N \to \infty} \frac{1}{N} \sum_{i=1}^{N} (x_i - x')^2$$

The square root of the variance is the standard deviation.

$$\sigma = \sqrt{\sigma^2}$$